AbstractID: 10703 Title: Electron Dose Kernels to Account For Secondary Particle Doses in Deterministic Simulations

Purpose: We developed a hybrid deterministic-Monte Carlo methodology called EDK-S_N, or “Electron Dose Kernel-Discrete Ordinates”. This methodology rapidly and accurately computes organ and whole body doses in human phantoms attributed to high energy photon irradiation from external beam therapy.

Methods and Materials: Full physics Monte Carlo (MC) calculations from MCNP5 were used to pre-compute electron dose kernels (EDKs) in energy bins to obtain the dose due to electrons in voxels (i', j', k'), generated as a result of incident primary photons at (i, j, k). Then, we employ voxelized phantoms to compute doses efficiently in two steps. First, we rapidly solve for the photon transport over the entire phantom using 3-D discrete ordinates (S_N) radiation transport on parallel computers using the PENTRAN-MP code system. Then, the detailed global S_N solution angular data throughout the phantom maps the dose to surrounding voxels; the dose is accumulated on each mesh, scaled by S_N photon fluence, using pre-computed EDKs.

Results: EDK-S_N and independent MCNP5 organ results are in good agreement; the largest statistical uncertainty (2σ) of the MC simulation near the source was less than 6%, and $<3\%$ on average. Moreover, the EDK-S_N hybrid method provided globally converged results in each voxel at sites distal to the source (in 3 hrs on 16 processors), and accurately yielded the whole body dose; equivalent MC results on the same computing platform had large uncertainties, and required substantially longer for equivalent accuracy (estimated at >200 hrs for equivalent statistical uncertainty).

Conclusions: A new methodology for accurate whole body or organ-specific 3D dose calculations has been developed based on S_N computations coupled to pre-computed EDKs based on full physics MC calculations. With the proper discretization and appropriate application of the EDK-S_N method, efficient and accurate 3D whole body doses can be determined for high energy photon beams.